

VIRGINIA (SSN 774) CLASS ATTACK SUBMARINE



Navy ACAT ID Program

Total Number of Systems:	30
Total Program Cost (TY\$):	\$65151M
Average Unit Cost (TY\$):	\$1995M
Full-rate production:	1QFY07

Prime Contractor

General Dynamics Electric Boat Division
Newport News Shipbuilding
Lockheed Martin Federal Systems (Combat System)

SYSTEM DESCRIPTION & CONTRIBUTION TO JOINT VISION 2010

VIRGINIA will replace the aging fleet of LOS ANGELES (SSN 688) submarines and is intended maintain the U.S. technological lead in undersea warfare well into the 21st century. VIRGINIA, formerly the New Attack Submarine, is intended to be a submarine comparable in most respects to its immediate predecessor, the SEAWOLF, but in a more affordable configuration. It is designed to rapidly deploy to militarily important hostile ocean areas and deny their use to the enemy, clear the way for strikes by other friendly forces, and engage and destroy enemy submarines, surface forces and land targets, supporting *dominant maneuver* as well as *full-dimensional protection* for afloat forces. VIRGINIA is to have a broad range of missions packaged in a quiet, fast, heavily armed, shock resistant, survivable submarine. These include Covert Strike Warfare, Anti-Submarine Warfare, Covert Intelligence Collection/Surveillance, Covert Indication and Warning and Electronic Warfare, Anti-Surface Ship Warfare, Special Warfare, Covert Mine Warfare, and Battle Group Support. VIRGINIA includes systems that incorporate technological advancements enabling greater ship quieting, improved acoustic sensors (with potential for subsequent growth), a flexible weapon load and ability to more quietly launch weapons, an advanced nuclear reactor, improved propulsion machinery, an advanced

propulsor-improved ship control, and enhanced survivability. VIRGINIA will use advanced technology and commercial-off-the-shelf (COTS) equipment to reduce acquisition and life cycle costs while retaining mission effectiveness.

VIRGINIA is required to be capable of targeting, controlling and launching MK 48 ADCAP torpedoes, mines, and Tomahawk missiles from anywhere in the ocean. Its sonar capability is expected to be similar to SEAWOLF's, and its electronic support suite and combat control system represent improvements over legacy systems. The external communications system is required to be an improvement over SEAWOLF and legacy systems, providing full, high data rate interoperability with U.S. and allied forces. These characteristics provide intelligence and strike capabilities to support the Joint Force Commander in *precision engagement*. VIRGINIA is required to maintain a level of stealth equivalent to the requirements of the SEAWOLF (SSN 21) class submarines. Other details are provided in the classified version of this report.

BACKGROUND INFORMATION

The Milestone I DAB approved VIRGINIA to enter Phase I in August 1994. For Milestone II, a very aggressive and thorough EOA of VIRGINIA was conducted in accordance with a DOT&E approved test plan, concluding that VIRGINIA was potentially operationally effective. More details are provided in the classified version of this report. The Program Office and Navy sponsor fully supported this EOA and generally agreed with the findings.

DOT&E recommended and the Secretary of Defense approved a statutorily allowed waiver to full-up, system level live fire test of VIRGINIA because such tests were considered unreasonably expensive and impractical. DOT&E approved the alternative LFT&E plan submitted in lieu of full-up system level LFT&E in June 1995. This plan includes a Ship Shock Test of VIRGINIA. The Milestone II DAB approved VIRGINIA to enter Phase II on June 30, 1995.

An OA, which supported a DAB Program Review in FY97, concluded that the VIRGINIA design should lead to a potentially operationally effective submarine. The OA identified three high and six moderate risk areas. More details are provided in the classified version of this report. Many of the issues identified during the FY97 OA were the results of programmatic decisions to scope back efforts or eliminated capabilities factored into the original estimates of the VIRGINIA performance baseline.

On September 30, 1998, the Navy and Electric Boat signed the construction contract for the first four NSSN hulls. The \$4.2 billion contract has Electric Boat as the prime contractor and Newport News Shipbuilding as a major subcontractor. On October 2, 1998, the first hull of the NSSN class officially became the USS VIRGINIA (SSN 774).

TEST & EVALUATION ACTIVITY

DOT&E approved Revision B to the TEMP, which included a revised LFT&E Strategy, in November 1998. This TEMP revision includes another OA, which requires an interim as well as a final report. In FY00, an interim report will be produced that addresses two of the three high risk areas identified in the 1997 OA: Exterior Communications System and Towed Arrays. The final report is due in late FY01.

The Submarine Combat Systems program office is conducting VIRGINIA sonar development. Its leading sonar program, commonly known as Acoustic Rapid COTS Insertion (ARCI), and later redesignated as the AN/BQQ-10 sonar series, is oriented towards the use of COTS technology to upgrade all classes of existing submarine sonars, including the SEAWOLF class. The series has four phases: Phase I upgrades towed array narrow band and spacial vernier processing; Phase II upgrades towed array very low frequency broad band signal processing; Phase III upgrades spherical array processing; and Phase IV upgrades high frequency sonar processing. Phases I and II, and a Phase IV Engineering Development Model are currently being operated and developed on SSN 688 class submarines. Phases III and IV are scheduled for shipboard delivery in FY00. The AN/BQQ-10 series sonar has a goal of a common COTS architecture for all U.S. submarine sonars by 2005-2007.

VIRGINIA Related ARCI/BQQ-10 Activity. (1) A Tactical Development Exercise (TACDEVEX), followed by scheduled DT/OT of ARCI/BQQ-10 Phase II sonar with TB-29 thin line towed array, occurred at sea in the Pacific on board USS LOUISVILLE during July 1999. Both the TACDEVEX and DT testing occurred. However, a material casualty aboard USS LOUISVILLE required cancellation of the planned operational test period. The planned OT event on USS LOUISVILLE was an element of a risk reduction effort used to provide confidence for funding authorization decisions. COMOPTEVFOR concluded that sufficient data were obtained during TACDEVEX to permit drawing conclusions with regard to the potential operational effectiveness and operational suitability of the 688 ARCI Phase II configuration and to eliminate rescheduling this portion of the Phase II test. An additional DT/OT segment to obtain risk reduction data for the Advanced Processor Build (APB) 99 software upgrade to the Phase II baseline occurred in November 1999. Results are not yet available. (2) A combined DT/OT of the ARCI/BQQ-10 Phase II sonar with TB-23 thin line array occurred at sea in the Atlantic on board USS HAMPTON during August 1999. A preliminary analysis of the Phase II testing in September indicates that the system is potentially operationally effective and suitable (with the caveat that the analysis is preliminary). The OA final report is not yet available. OPEVAL of the Phase II+ system (10 ship sets of this version of the ARCI upgrade to 688 class submarines that are TB-29 capable are planned to be introduced to the fleet and operated for several years before being upgraded to Phase III) is planned to occur in the summer of 2000, followed closely by OPEVAL of Phase III and IV systems on SSN 688I submarines. FOT&E is preliminarily planned for 2002 to evaluate BSY-1 (ARCI upgrade) with the next-generation TB-29 towed array.

Technical testing to improve the acoustic performance of VIRGINIA propulsor development continued throughout the year. More details are provided in the classified version of this report

An Operational Assessment (OT-IIA2) of the VIRGINIA Class has begun. This two-phased assessment will first produce an interim report (FY00) that examines areas identified as high risk during OT-IIA1 (e.g., towed arrays and external communications systems) and provide a final report that will assess systems and Critical Operational Issues (FY01). A significant portion of this OA will utilize the Naval Undersea Warfare Center's (NUWC) submarine-versus-submarine simulation programs (SIM II/SSTORM II) to evaluate performance under recent threat and VIRGINIA sub-system changes. Much of FY99 was spent assessing the submarine and weapons performance computer models used by NUWC. This effort included attempts to accredit NUWC computer models using current Office of Naval Intelligence and Defense Intelligence Agency threat data. Computer-modeled performance runs are scheduled to occur in FY00.

COMOPTEVFOR has begun using the Naval Security Group to assist them in evaluating the vulnerability of VIRGINIA's combat and ship control systems local area network. This assessment will include looks at outside attack, internal attack, and inadvertent error.

Other notable factory, model, and prototype testing included: (1) 1/20th scale hull form hydrodynamic testing; (2) Lightweight Wide Aperture Array sonar performance and environmental testing; (3) AN/BLQ-10 (V) Electronics Surveillance Measures System factory acceptance testing; (4) Ring Laser Gyroscopic Navigator magnetic field susceptibility qualification testing; (5) Sonar and Combat System information architecture subsystem testing; (6) AN/BLQ-10 Photonics Mast engineering developmental model testing; (7) A/B-1 weapons delivery system UNDEX component shock testing; (8) Main Air Conditioning Unit engineering developmental model testing; (9) Reverse Osmosis Unit prototype testing on an operational SSN 688 submarine; (10) High Speed Emergency Diesel Generator engine functional qualification testing; and (11) Integrated Low Pressure Electrolyzer acoustic and electronics emission testing.

In FY99, DOT&E reviewed and twice commented on the Navy's September 1998 Update I of the VIRGINIA detail design vulnerability assessment report (VAR) and the Navy's actions to resolve DOT&E's VAR comments. DOT&E participated in VIRGINIA working group meetings and provided insight as well as oversight on Navy planning for future LFT&E events. DOT&E witnessed and reviewed the results of Live Fire component and surrogate tests including an extensive series of underwater shock tests of the A/B-1 test vehicle.

TEST & EVALUATION ASSESSMENT

In FY98, ARCI/BQQ-10 Phase I was determined to be potentially operationally effective and suitable. Six high-risk areas and a number of areas of moderate risk were identified, and a second ARCI/BQQ-10 Phase I operational test was conducted. More details are provided in the classified version of this report.

In FY99, ARCI/BQQ-10 moved into Phase II development with an initial acquisition strategy that called for installation on two submarines with developmental testing, operational testing, and subsequent installation on fourteen additional submarines, contingent upon demonstrated satisfactory operational test performance. This Phase II configuration was planned as a "baseline" software build. A second Phase II version, known as Phase II with APB-99 (for Advanced Processor Build), was expected to follow the baseline version in late FY99, but the Navy decided to accelerate APB-99 development. As a result, ARCI Phase II software updated with APB-99 improvements (informally known as ARCI Phase II+) will be ready for installation well before the dates initially planned. The "Phase II+" ARCI/BQQ-10 configuration is now planned to be the incremental fleet introduction version. This acceleration was not codified in the TEMP, thereby establishing a situation in which fleet introduction of the Phase II+ system beyond the ship sets required to support testing could have preceded adequate operational testing. DOT&E informed the Navy that the ARCI/BQQ-10 TEMP required immediate updating, including clear delineation of operational test events that precede the installation decision for each Phase of ARCI/BQQ-10. DOT&E is also concerned that inadequate operational testing time is being expended in the assessment of the ARCI/BQQ-10 program. In one case, the Navy depicted some testing as operational although DOT&E considered the testing more developmental in nature. A DOT&E review of ARCI operational testing concluded that relatively few discrete operational testing events have been performed. Instead, almost all testing has been performed in a combined DT/OT format. Though such efforts are one cornerstone of acquisition reform (and DOT&E agrees that combined DT/OT is valuable), it may be that this program could benefit from a shift toward more stand-alone operational test periods in which test platforms and targets are provided sufficient time to conduct robust operational performance assessments. DOT&E believes that separate and distinct OPEVALs, which include formal operational test readiness reviews, are still valuable to the overall integrity of the acquisition process. DOT&E has

brought these concerns to the Navy's attention, and the Navy has agreed to update and keep the ARCI/BQQ-10 TEMP in agreement with the Navy's acquisition strategy. The Navy has indicated that independent at sea OPEVAL of the ARCI Phase II+ and ARCI Phase III are planned for FY00. The Navy is also now reviewing the content for FOT&E to evaluate other aspects of ARCI/BQQ-10 that IOT&E will not address.

Propulsor development and performance continue to receive central focus as a result of SEAWOLF class problems in this area. The program office is attempting to improve the correlation between VIRGINIA propulsor modeling and simulation and empirical data by comparing SEAWOLF performance predictions with observed performance since both programs have used the same prediction models. More details are provided in the classified version of this report. It is probable that the Navy will first try-out a VIRGINIA propulsor at sea on SEAWOLF, giving the VIRGINIA program an opportunity to further refine its propulsor, if necessary. DOT&E continues to closely follow this issue.

The Light Weight Wide Aperture Array (LWWAA) sonar experienced development problems during FY99. The LWWAA consists of six Light Weight Planar Arrays (LWPA) mounted three to each side of the submarine's hull. This sonar will use first-of-a-kind fiber-optic, laser-excited hydrophones contained in a LWPA, whose affordable development was seriously lagging the submarine construction schedule. Heightened program office management attention has alleviated much of the risk in development of LWPA and other outboard components, but significant risk remains for inboard electronics. DOT&E anticipates that the LWWAA will be identified as a risk issue in COMOPTEVFOR's preliminary OA report scheduled for April 2000.

The 1997 OA cited the Exterior Communications System as high risk. ECS must be fully capable to assure VIRGINIA's Battle Group and Joint Interoperability. The high data rate antenna and reduced equipment rack availability (nine racks for VIRGINIA as opposed to fourteen racks for the SSN 688 class) are particular challenges. The VIRGINIA program office has downplayed the significance of only nine available radio equipment rack locations, pointing out that VIRGINIA's internal radio equipment volume actually exceeds the SSN 688 class. Investigations with design engineers, however, point out that equipment accessibility for operator control is a problem, so issues remain to be resolved to ensure that accessibility to radio equipment controls is adequate. Navy management attention in this area is significant, however, so DOT&E now considers ECS risk moderate.

COMOPTEVFOR is working to accredit the NUWC computer performance models, which unfortunately have no previous accreditation pedigrees. To help, COMOPTEVFOR formed an Integrated Product Team to begin an accreditation effort. DOT&E is actively involved in this process, providing analytical assistance. The effort has two parts: (1) examination of the administrative control aspects of the models (e.g., quality assurance and configuration management); and (2) investigation of model inputs, outputs, and algorithms as a means of accrediting the model. Two new and significant efforts have been agreed to for FY00: (1) a subset of simulation runs will be examined in detail with the goal of understanding any substantial differences between model inputs/outputs and actual in-water observations; and (2) an excursion will be conducted in which free-play operational search scenarios will be simulated. This should allow for the estimation of search-related measures of effectiveness that can then be compared to data collected during operational test. This excursion will also serve as a baseline case (of free-play search simulation) from which future SIM II/SSTORM II excursions may be performed. If the above procedures are actually conducted, they should be adequate for COMOPTEVFOR's accreditation requirements.

The Navy has evaluated six damage scenarios for the detail design VAR using linear extrapolation from physics-based design-level shock analyses in local environments to 10 percent above

the design level. The Navy is proposing a “Meaningful Drill Concept” for the post-delivery Total Ship Survivability Trial (TSST) with damage scenarios that are to be tied back to the six shot lines. However, the damage scenarios for these shot lines have not been developed to reflect the effects of secondary damage (e.g., fire, flooding, hydraulic leak, loss of control circuits, etc.). Due to modeling and simulation limitations, as well as funding constraints, the Navy has declined to extrapolate analysis of the six damage scenarios to levels higher than 10 percent above the design level. How the Navy intends to choose TSST scenarios that will realistically depict damage scenarios is uncertain. DOT&E will continue to work with the Navy to resolve this issue.

CONCLUSIONS, RECOMMENDATIONS, LESSONS LEARNED

The Navy needs to maintain test discipline within the AN/BQQ-10 Sonar program. The Navy is being innovative, aggressive, and initially successful in its development of usable Commercial-Off-the-Shelf computer systems for submarine sonar applications, but history has shown that ample, robust, and independent operational testing is essential for ultimate program success.

The Navy needs to develop realistic scenarios for TSST that include the effects of secondary damage. DOT&E will work closely with the Navy to ensure that scenarios developed for TSST are appropriate and include the effects of secondary damage.